

A Research Note

CORRELATION OF NONDESTRUCTIVE MEASUREMENTS AND SOLUBLE SOLIDS FOR ROME BEAUTY AND YORK IMPERIAL APPLES

ABSTRACT

Relationships between nondestructive measurements and other indices of fruit composition or condition in Rome Beauty, York Imperial, Red Spur Delicious, and Golden Delicious apples were studied. Fruits were subjected to different storage and ripening treatments before being analyzed individually by various nondestructive and destructive procedures. Of the procedures tested, potentially useful correlations were obtained between nondestructive spectrophotometric measurements and juice soluble solids with Rome Beauty and York Imperial apples.

INTRODUCTION

A NUMBER of objective indices have been proposed for the measurement of apple maturity or ripeness (Anon, 1965). Such measurements, especially those performed nondestructively, might be used to grade or sort apples for fresh market or processing.

Relationships between nondestructive measurements and other indices of apple condition or composition must be established if nondestructive measurements are to be used as predictors of the state of the fruit. Previously, we reported correlations between values of the stiffness coefficient (or firmness index), determined by nondestructive measurement of sonic resonance frequency, and levels of volatile components, acidity, and firmness in McIntosh apples (Sapers et al., 1977). Finney et al. (1978) obtained correlations between the firmness index, Magness-Taylor firmness, and sensory ratings of textural attributes for five apple cultivars. At this time, we report correlations between juice soluble solids and various nondestructive measurements obtained with Rome Beauty and York Imperial apples.

MATERIALS & METHODS

Materials and experimental design

Samples of Rome Beauty, York Imperial, Red Spur Delicious, and Golden Delicious apples were provided by the USDA's Beltsville (Md.) Agricultural Research Center from fruits obtained from a commercial Pennsylvania orchard. The apples were harvested at weekly intervals over a 3–4 wk period in 1975, bracketing the time of normal harvest, and stored in Beltsville at 0°C and 80–90% RH. Random samples of 20 apples per harvest were removed from storage after 1–2 months and again after 5–6 months; half of each sample taken from storage was held at 18–20°C for 1 wk to permit ripening. Apples were coded so that analytical data for individual fruits could be collated.

Analytical measurements

Nondestructive measurements were made at the Beltsville laboratory on ripened and unripened apple samples. Visible absorption spectra (absolute optical density values taken at 10 nm intervals between 640 and 880 nm) were obtained with a computer-assisted high intensity spectrophotometer which was capable of measuring light transmitted through intact fruits (Massie and Norris, 1975). Differences in absorbance between 700 and 740 nm (ΔA 700/740),

a potential index of maturity based on the internal chlorophyll content of apples (Aulenbach et al., 1972), were used to select six apples from each sample to provide a range of maturities. Differences in absorbance for a second wavelength pair representing a maximum (680 nm) and a minimum (720 nm) were also calculated from the spectra and expressed as ΔA 680/720. In addition, the selected apples were analyzed by the procedure of Finney (1972) for sonic resonance frequency, and values of the firmness index f^2m (dynes/cm) were calculated.

After the completion of the nondestructive measurements at Beltsville, the coded apple samples were shipped to our Center where they were analyzed individually by destructive procedures described previously (Sapers et al., 1977), thereby permitting the direct comparison of nondestructive and destructive data obtained for each apple. Apple firmness (in pounds) was measured with a Magness-Taylor pressure tester. The juice of individual apples was extracted with an Acme Supreme Juicerator Model 6001 (Acme Juicer Manufacturing Co., Lemoyne, Pa.) and analyzed for soluble solids with a refractometer and for titratable acidity (as % malic acid).

Statistical analyses

Relationships between objective measurements were examined by correlation analysis, performed on the entire data set for each cultivar as well as on subsets representing different ripeness and storage combinations since these treatments were expected to influence fruit condition. Tests of significance were based on at least 16 degrees of freedom.

RESULTS & DISCUSSION

DURING RIPENING and storage, the apple samples changed in firmness and juice composition, producing a wide range of analytical values for the individual fruits (Table 1). Correlations between physical measurements performed on individual apples and the composition of the juice were examined for relationships which might be of potential value in predicting fruit maturity, ripeness, or quality.

Significant and potentially useful correlations were found between nondestructive spectrophotometric measurements, performed on intact fruit, and the soluble solids content of juice from Rome Beauty and York Imperial apples (Table 2). Correlation coefficients were similar for data acquired at the two wavelength pairs (680/720 and 700/740 nm). Firmness index values for these apples also correlated with juice soluble solids, although correlation coefficients were lower. Correlations were usually higher with ripened than with unripened fruits. Red Spur Delicious and Golden Delicious apples generally did not yield significant correlations (at the 5% level) between these measurements. Correlations between other nondestructive and destructive measurements were too low or limited in applicability to be of any practical value.

The relationship between juice soluble solids and nondestructive spectrophotometric measurements can be described by regression equations such as Eq (1) and (2) for ripened Rome Beauty and York Imperial apples, respectively, both analyzed at 680 and 720 nm.

$$\text{Soluble solids} = 14.6 - 0.91 \Delta A \text{ 680/720} \quad (1)$$

$$\text{Soluble solids} = 12.9 - 0.44 \Delta A \text{ 680/720} \quad (2)$$

Each of the Rome Beauty subsets in this study yielded

Table 1—Analytical measurements for Rome Beauty and York Imperial apple samples^a

Measurement	Rome Beauty			York Imperial		
	Mean	Std. dev.	Range	Mean	Std. dev.	Range
Destructive						
Magness-Taylor (kg)	4.6	0.4	3.1 — 6.0	6.9	1.0	4.6 — 9.3
Acidity (% malic)	0.38	0.09	0.18 — 0.64	0.38	0.09	0.20 — 0.58
Soluble solids (%)	12.1	1.1	8.9 — 14.4	12.2	0.7	10.6 — 14.4
Nondestructive						
ΔA 700/740 ^b	0.18	0.35	(-0.38) — 0.87	0.02	0.25	(-0.30) — 0.72
ΔA 680/720 ^b	2.79	1.02	0.89 — 4.16	1.98	1.00	0.62 — 4.03
Firmness index f ² m (dynes/cm X 10 ⁻⁶)	148	12	130 — 185	176	15	142 — 219
No fruits		94			72	

^a For all storage and ripening treatments^b Absorbance difference between 700 and 740 or 680 and 720 nm

Table 2—Correlation between nondestructive measurements and juice soluble solids

Cultivar	Nondestructive measurement	Correlation coefficient			
		Stored 1—2 months		Stored 5—6 months	
		Ripened ^a	Not ripened	Ripened ^a	Not ripened
Rome Beauty	ΔA 700/740	-0.91 ^b	-0.78 ^b	-0.84 ^b	-0.82 ^b
	ΔA 680/720	-0.91 ^b	-0.73 ^b	-0.86 ^b	-0.83 ^b
	f ² m	0.64 ^b	0.44 ^c	0.45 ^c	0.42 ^c
York Imperial	ΔA 700/740	-0.79 ^b	-0.40	-0.77 ^b	-0.61 ^b
	ΔA 680/720	-0.77 ^b	-0.38	-0.78 ^b	-0.65 ^b
	f ² m	0.66 ^b	0.57 ^c	0.72 ^b	0.62 ^b

^a 1 wk at 18–20°C^b Significant at 1% level^c Significant at 5% level

similar regression coefficients; slopes differed, however, for York Imperial subsets. Relationships such as Eq (1) might be made the basis of automated procedures for grading, sorting or blending Rome Beauty apples for juice production. Practical applications of this kind, however, must be preceded by further research to establish the validity of the

method for widely differing raw material sources, growing conditions, and storage conditions.

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Reference to a brand or firm name does not constitute endorsement by the U.S. Department of Agriculture over others of a similar nature not mentioned.